INDOOR AIR QUALITY ASSESSMENT

Johnny Appleseed Elementary School
845 Main Street
Leominster, MA 01453

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of the Leominster Health Department, the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at each of Leominster's public schools. These assessments were jointly coordinated through Chris Knuth, Director of the Leominster Health Department, and David Wood, Facilities Director for Leominster Public Schools (LPS). On June 7, 2005, Sharon Lee, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an assessment at the Johnny Appleseed Elementary School (JAES), 845 Main Street, Leominster, Massachusetts.

The JAES is a two-story brick building constructed in 1956. An addition was made in 1991. The main level is built atop a hill, and portions of the lower level abut the hill. The school is located at the intersection of two main roads. The school consists of classrooms, a gym, music room, media and computer centers, art room, cafeteria and offices. Windows throughout the building are openable.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization

Detector (PID). MDPH staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 710 kindergarten through fourth grade students and approximately 100 staff members. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million (ppm) of air in nine of fifty areas, indicating adequate air exchange in the majority of areas surveyed. It is important to note that some areas had open windows or were empty or sparsely populated at the time of assessment. Open windows and low occupancy can reduce carbon dioxide levels. Carbon dioxide levels would be expected to be higher with full occupancy and with windows closed.

Fresh air in classrooms is mechanically provided by unit ventilator (univent) systems equipped with high efficiency pleated filters (Pictures 1 and 2). A univent draws air from the outdoors through a fresh air intake located on the exterior wall of the building (Picture 3) and returns air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Univents were operating at the time of the assessment. Obstructions to airflow, such as desks and other items located on or in front of univents, were observed in some classrooms

(Picture 4). To function as designed, univents must be allowed to operate and remain free of obstructions.

Exhaust ventilation is provided by ceiling- or closet-mounted exhaust vents (Pictures 5 and 6), which are ducted to motorized fan units. For rooms with closet exhausts, classroom air is drawn through a space beneath the closet door, into the closet (Picture 7), and out the vent in the ceiling of the closet. Some doors were undercut insufficiently (less than 1 inch); therefore, draw of air into the closet would be difficult. Closet exhaust vents are also prone to obstruction by items placed in front of floor level openings and/or on shelves below the vent (Picture 8). Some closet exhaust vents were off, drawing weakly and/or backdrafting in some classrooms (Table 1). As with the univents, exhaust vents must be allowed to operate and remain free of obstructions. Some ceiling-mounted exhaust vents were located near hallway doors (Picture 9); the location of these exhausts can result in limited exhaust efficiency. When classroom doors are open, exhaust vents will tend to draw air from both the hallway and the classroom, reducing the effectiveness of the exhaust vent to remove common environmental pollutants.

Common areas (e.g., cafeteria, gymnasium) and some offices are ventilated by rooftop air handling units (AHUs). Fresh air is supplied through ceiling-or wall-mounted air diffusers and ducted back to the AHUs via return vents. At the time of the assessment, ventilation for the cafeteria did not appear to be operating, nor were ceiling fans, which serve to increase air circulation in the cafeteria.

In addition, some classrooms had window- or wall-mounted air-conditioners. A number of these classrooms had air-conditioning operating in the cooling setting with windows and/or classroom doors open. Open windows and doors allow unconditioned air to enter the classroom. Operating the air-conditioner under these conditions reduces its efficacy to cool classrooms. In addition, this may result in condensation formation on the floor near the hallway or on windows. If an increased amount of fresh air to the classroom is desired, occupants should operate the air-conditioner in the fan-only setting. In this setting, unconditioned fresh air is mechanically supplied to the room.

To maximize air exchange, the MDPH recommends that ventilation equipment operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). It was reported by Mr. Wood that the LPS has a contract with Pioneer Valley Environmental, Inc., an HVAC engineering firm that conducts preventive maintenance of HVAC equipment in all of Leominster's public schools. The preventative maintenance program consists of an annual assessment of all HVAC system components (e.g., univents, AHUs, pneumatic controls, thermostats). A detailed report is generated and provided to the LPS facilities department to address needs.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

The temperature measurements ranged from 73^{o} F to 83^{o} F, which were within or slightly above the MDPH recommended comfort guidelines (Table 1). The MDPH recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, temperature control is often difficult without operating the ventilation systems as designed (e.g., univents/exhaust vents deactivated/obstructed). Furthermore, thermal comfort during spring/summer months is difficult to achieve without the aid of a mechanical cooling system.

The relative humidity measurements ranged from 34 to 64 percent, which were close to the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. The sensation of dryness and irritation is common in a low relative humidity environment. Relative humidity levels in the building would be expected to drop during the winter months due to heating. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A number of rooms had water-stained ceiling tiles (Picture 10). Water-damaged ceiling tiles can indicate a leak(s) in the roof and/or pipes. Water-damaged ceiling tiles can provide a source of mold growth and should be replaced after a water leak is discovered and repaired. Appropriate measures should also be taken to minimize the aerosolization of particulates from tile removal/replacement.

Other sources for water damage were also observed. Open seams between the sink countertop and backsplash were observed in several rooms (Picture 11). In one case, the backsplash was observed to be swelling (Picture 12). If not watertight, water can penetrate through the seams between backsplashes and countertops. Water penetration and chronic exposure of porous and wood-based materials can cause these materials to swell and show signs of water damage.

The American Conference of Governmental Industrial Hygienists (ACGIH) and United States Environmental Protection Agency (US EPA) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (ACGIH, 1989; US EPA, 2001). If items are not dried within this time frame, mold growth may occur. The application of a mildewcide to mold colonized porous materials is not recommended.

At the time of the assessment, water was leaking out of the univent in classroom 2E. Staff indicated that a problem existed with the univent's compressor. The appropriate replacement parts were on order. Staff indicated that once the parts were received, the appropriate replacements would occur.

A number of conditions observed along the building exterior may be conducive to water penetration through the building envelope. Missing/damaged mortar around masonry was observed in several areas (Pictures13 and 14). Holes, breaches, and seams are points through which water can penetrate the building, particularly under driving rain conditions. The gutter/downspout system was damaged/missing in several areas (Picture 15), and the base of the exterior wall appeared to be moistened. Chronic exposure of the exterior brickwork and foundation to water can provide a source for water intrusion and, overtime, result in structural damage. In addition, breaches can serve as points of entry or shelter for pests.

Shrubbery and other plants were observed to be growing in cracks and crevices in close proximity to foundation walls (Picture 16). The growth of roots against exterior walls can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the foundation below ground level. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

Plants were observed in several classrooms. Plants should be properly maintained and equipped with drip pans. Some plants were placed near ventilation sources (Picture 17). Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should not be placed directly on carpeting and should be located away from univent air diffusers to prevent the aerosolization of dirt, pollen or mold. In one classroom, a garden with wood chips and plants was placed on a carpeted area (Picture 18). It is unclear whether the basin holding the wood chips and plants is lined with plastic. If unlined and/or the basin were to leak, water could damage the carpeting below. The potential for mold growth exists if the carpeting remained moist and the damage were undiscovered. In addition, since wood chips retain moisture, they can be a source for odors and mold growth.

A rubber gasket for a classroom window was also failing (Picture 19). These breaches can serve as points for water entry and/or drafts into the building. Continued freezing and thawing of water during cooler months will serve only to cause further damage.

Lastly, a number of aquariums and terrariums were noted in classrooms. Aquariums should be properly maintained to prevent microbial/algae growth, which can emit unpleasant odors. Similarly, terrariums should be properly maintained to ensure soil does not become a source for mold growth.

Other IAQ Evaluations

Indoor air quality can also be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were 1 ppm (Table 1). Carbon monoxide levels measured in the school ranged from ND to 1 ppm. As previously discussed, the JAES is at the corner of two frequented roads. Carbon monoxide readings outdoors are likely from vehicular traffic. Indoor carbon dioxide levels reflect outdoor carbon monoxide levels.

The US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 µm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter (µg/m^3) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, the US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 µg/m^3 over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 29 µg/m^3 (Table 1). PM2.5 levels measured indoors were in a range of 14 to 32 µg/m^3, which were below the NAAQS of 65 µg/m^3. Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can also generate particulates during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system; cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC concentrations were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use TVOC containing products. While no TVOC levels measured exceeded background levels, materials containing VOCs were present in the school. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

A container of rubber cement was observed in one classroom. Rubber cement contains n-hexane or heptane, which can be irritating to the eyes, nose and throat. Local exhaust ventilation should be utilized when this material is in use. As required by the federal Labeling of Hazardous Art Materials Act (LHAMA), art supplies containing hazardous materials that can cause chronic health effects must be properly labeled (USC, 1988). The use of such art supplies should be limited to times when students are not present and in areas where adequate exhaust ventilation is available. Rubber cement not only contains VOCs but also is flammable material and should be stored in a flameproof cabinet.

Cleaning products were found on countertops and in unlocked cabinets beneath sinks in some classrooms (Picture 20). Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. In addition, plug-in air fresheners/deodorizers were in use in some classrooms. These products contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. Furthermore, air fresheners do not remove materials causing odors, but rather mask odors that may be present in the area.

Several other conditions that can potentially affect indoor air quality were identified. Exhaust vents and fan blades to personal fans were occluded with dust. Reactivated fans can serve to distribute accumulated dust. If exhaust vents become deactivated, backdrafting can occur, resulting in the re-aerosolization of accumulated dust particles. Also of note was the amount of materials stored inside classrooms. In several areas, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items hanging from the ceiling tile system were noted in a number of areas. Missing and ajar ceiling tiles create pathways for dust, dirt, odors and other pollutants to move into occupied areas. Dust can be irritating to the eyes, nose and respiratory tract. For this reason, items should be relocated and/or cleaned periodically to avoid excessive dust build up. Accumulated chalk dust was noted in some classrooms. Chalk dust is a fine particulate that can easily become aerosolized, irritating eyes and the respiratory system.

A number of classrooms contained upholstered furniture and pillows. Upholstered furniture is covered with fabric that encounters human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent (e.g., during spring/summer), dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, 1994). It is also recommended that if upholstered furniture were present in schools, it should be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICRC, 2000).

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 21). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g. spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998). Consider replacing tennis balls with alternative glides (Picture 22).

Pets were observed in some classrooms. Cages are lined with wood shavings. Porous materials (i.e., wood shavings) absorb animal wastes and can be a reservoir for mold and bacterial growth. Animal dander, fur and wastes can all be sources of respiratory irritants. Animal cages should be cleaned regularly to prevent the aerosolization of allergenic materials and/or odors. Birds' nests were observed in classrooms some (Picture 23). Nests can contain bacteria and may be a source of allergenic material. Nests should be placed in resealable bags to prevent aerosolization of allergenic material and be kept out of the airstream of univents.

Finally, of note was the observation of re-use of food containers for projects (Pictures 24 and 25). Food is an attractant to pests and rodents. Reuse of food containers (e.g., for art projects) is not recommended since food residue adhering to the container surface may serve to attract pests.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Examine exhaust vents for function and make repairs as necessary.
2. Examine undercut closet doors and, where necessary, increase space between door and floor.
3. Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange.
4. Remove all obstructions from univents and exhaust vents to facilitate airflow. Close classroom doors to improve air exchange.
5. Remove debris and dust accumulated on ventilation grilles and fan blades.
6. Use openable windows in conjunction with classroom exhaust vents to facilitate air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
8. Identify and repair sources of water leaks. Replace water-damaged ceiling tiles. These ceiling tiles can be a source of microbial growth. Examine the non-porous surface

beneath the removed ceiling tiles and disinfect with an appropriate antimicrobial. Appropriate measures should also be taken to minimize the aerosolization of particulates from tile removal/replacement.

9. Consider repointing building exterior. Seal breaches to the building exterior to prevent pest and water intrusion.
10. Replace missing downspout. Examine gutter/downspout system periodically to ensure gutters are free of debris, and downspouts are intact.
11. Remove plants growing against the building and its foundation to prevent water intrusion through brickwork.
12. Clear plant growth and other materials/debris away from the proximity of univent air intakes.
13. Examine plants in classrooms for mold growth in water catch basins. Disinfect water catch basins if necessary. Remove plants from ventilation sources and carpeted areas.
14. Consider removing classroom garden to prevent odors and potential mold growth.
15. Clean and maintain aquariums and terrariums to prevent bacterial/microbial growth and associated odors.
16. Clean chalkboards and dry erase board trays regularly to avoid the build-up of particulates.
17. Store cleaning products properly and out of reach of students. Ensure spray bottles are properly labeled.
18. Ensure rubber cement is stored properly. Use rubber cement in well ventilated areas.
19. Refrain from using strongly scented materials (e.g., air fresheners) in classrooms.

20. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

21. Store nests in resealable bags, away from ventilation sources.

22. Refrain from hanging objects from ceiling tile systems.

23. Consider replacing tennis balls with alternative glides.

24. Refrain from re-using food containers as materials for projects.

25. Consider adopting the US EPA document, *Tools for Schools* (US EPA, 2000b), as a means to maintaining a good indoor air quality environment in the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

26. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://mass.gov/dph/indoor_air

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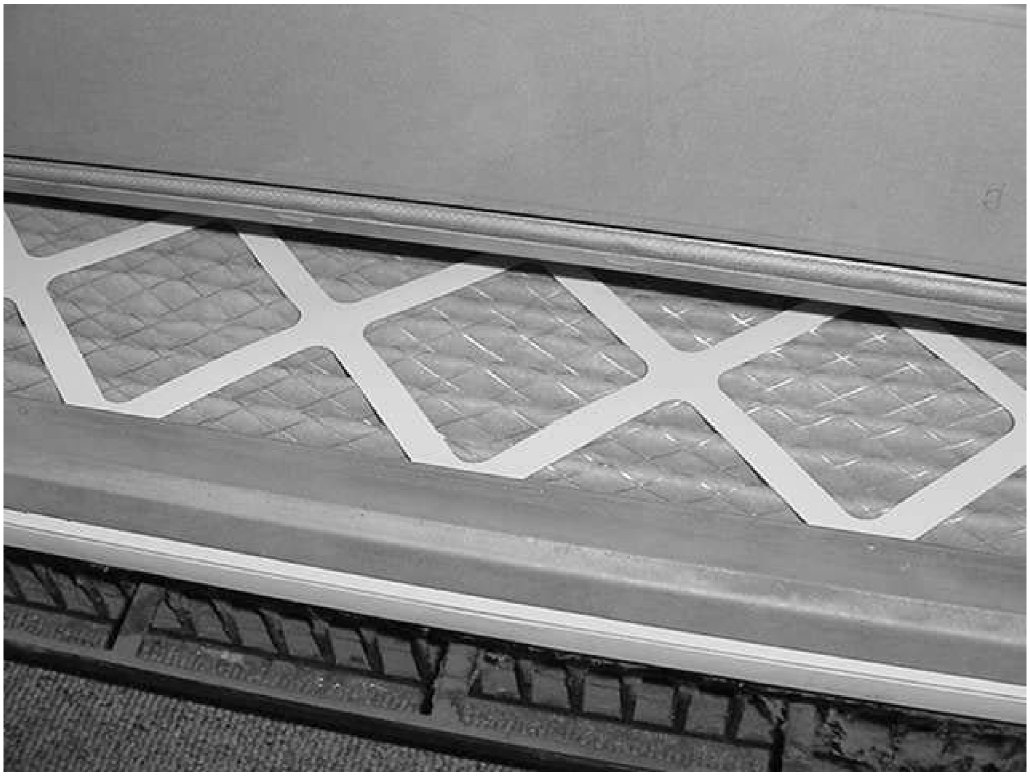
Picture 1

Classroom Univent

Picture 2



High Efficiency Pleated Air Filter in Univent

Picture 3

Univent Fresh Air intake, Note Proximity of Plants/Shrubbery

Picture 4

Univent Return Vent (Bottom Front) Obstructed by Furniture in Classroom

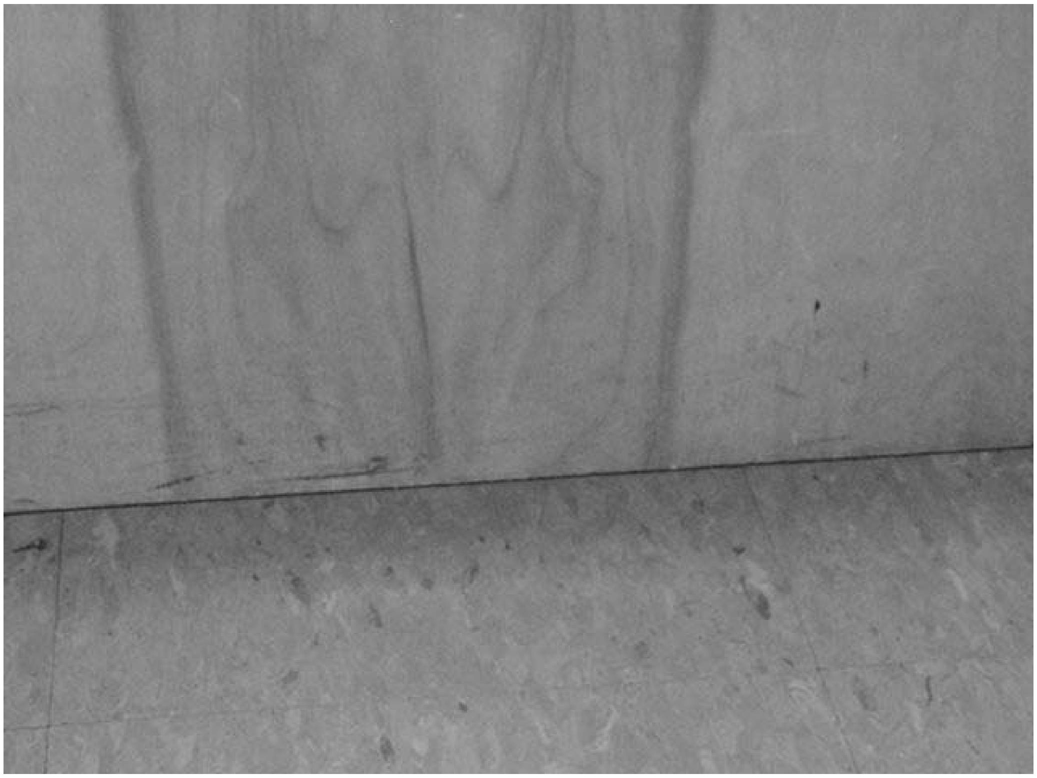
Picture 5

Ceiling-Mounted Exhaust Vent

Picture 6

Coat Closet Exhaust Vent

Picture 7



Coat Closet Door, Note Small Undercut at Bottom at Door Limiting Airflow into the Closet

Picture 8

Exhaust Vent Blocked by Various Items

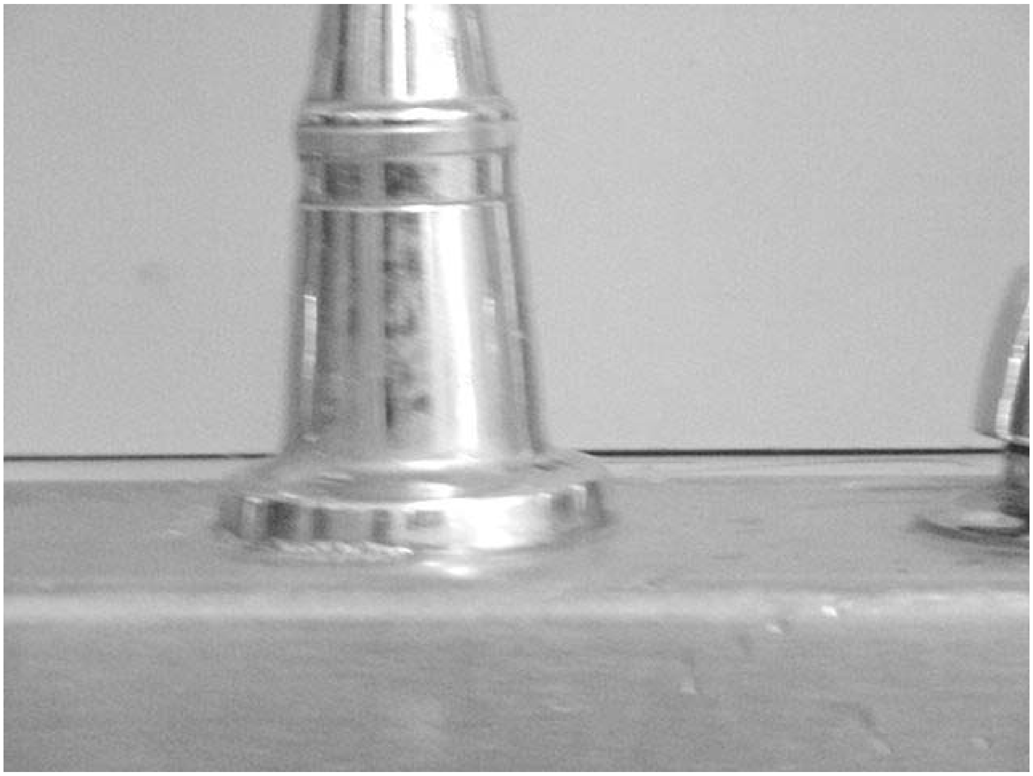
Picture 9

Proximity of Exhaust Vent to Classroom Door

Picture 10

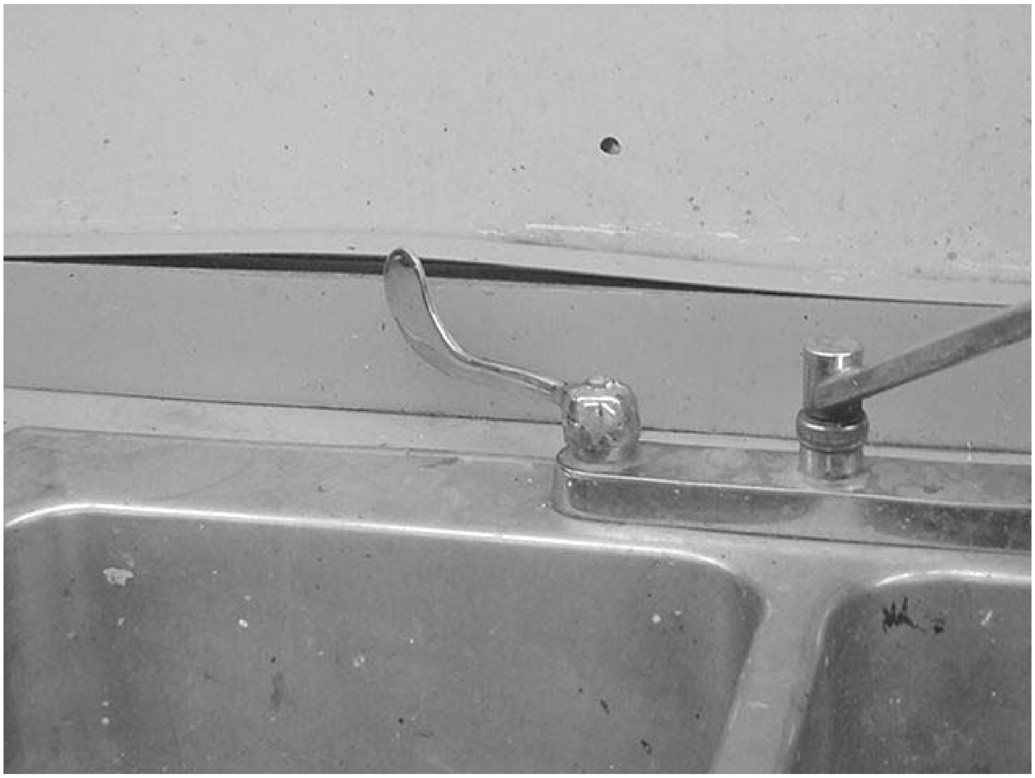
Water Damaged Ceiling Tile

Picture 11



Open Seam between Sink Countertop and Backsplash

Picture 12



Swelling Particleboard Backsplash

Picture 13

Damaged Foundation

Picture 14

Damaged Brickwork on Exterior Wall

Picture 15

Missing Portion of Downspout/Elbow Extension

Picture 16

Plants Growing between Exterior Wall and Tarmac

Picture 17

Plant and Pencil Sharpener Near Univent Air Diffuser

Picture 18

Indoor Garden on Carpet in Classroom

Picture 19

Failing Rubber Window Gaskets in Classroom

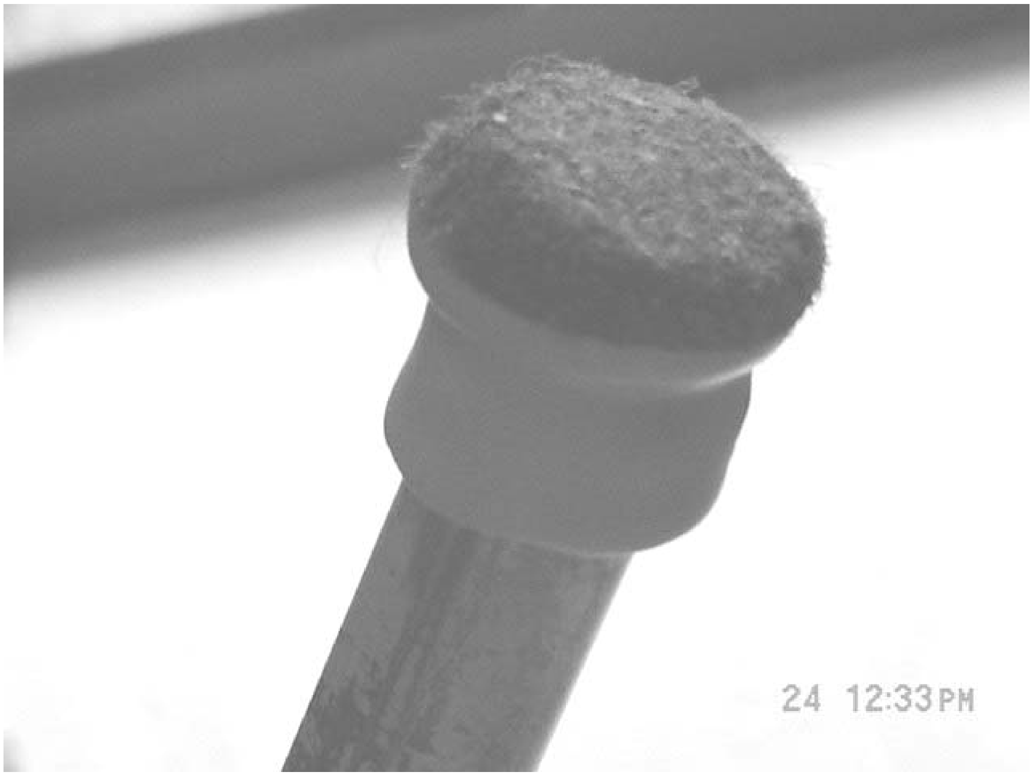
Picture 20

Spray Bottles of Cleaning Products in Unlocked Classroom Sink Cabinet

Picture 21

Tennis Balls on Chair Legs

Picture 22



Alternative “glides” for chair legs

Picture 23

Birds Nest in Classroom

Picture 24

Empty Milk Containers for Projects

Picture 25

Empty Egg Containers for Projects

Johnny Appleseed Elementary School

845 Main Street, Leominster, MA 01453

Table 1

Indoor Air Results

Date: 06/07/2005

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background	0	73	41	389	1	ND	29				Sunny, school off major road.
26	26	78	64	972	1	ND	26	Y # open: 0 # total: 2	Y univent	Y ceiling	Hallway DO, PF, items, items hanging from CT.
4C	19	80	56	522	1	ND	26	Y # open: 3 # total: 4	Y univent	Y ceiling dust/debris	Hallway DO, DEM, PF, items hanging from CT, near back parking.
4B	0	80	53	474	1	ND	28	Y # open: 2 # total: 4	Y univent	Y ceiling	Hallway DO, CD, DEM, UF, near back parking.
4A	8	79	56	895	1	ND	26	Y # open: 0 # total: 4	Y univent dust/debris plant(s)	Y ceiling	Hallway DO, DEM.
D2	2	78	52	566	1	ND	22	N	Y univent	Y ceiling	Hallway DO, #WD-CT : 3, DEM.
gym	0	77	53	483	1	ND	26	N	Y ceiling	Y wall dust/debris	Exterior DO,

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Johnny Appleseed Elementary School **Indoor Air Results**

845 Main Street, Leominster, MA 01453 **Date: 06/07/2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
4E	10	77	56	1171	1	ND	22	Y # open: 0 # total: 2	Y univent	Y ceiling	Hallway DO, DEM, UF, items, items hanging from CT.
4F	12	78	56	895	1	ND	27	Y # open: 0 # total: 4	Y univent	Y ceiling	Hallway DO, DEM, items.
ES	6	78	54	776	1	ND	27	Y # open: 1 # total: 2	Y univent	Y ceiling	Hallway DO, DEM, TB.
4G	11	78	56	963	1	ND	26	Y # open: 0 # total: 4	Y univent	Y ceiling	Hallway DO, DEM, items, items hanging from CT.
art	1	78	54	617	1	ND	16	Y # open: 0 # total: 4	Y univent	Y ceiling	Hallway DO, breach sink/counter, #MT/AT: 1, cleaners.
occupational therapy	0	78	54	525	1	ND	25	Y # open: 2 # total: 2	Y univent	Y ceiling location	DEM, plants.

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3G	0	81	49	425	1	ND	22	Y # open: 1 # total: 3	Y univent (off) items	Y closet	Hallway DO, Inter-room DO, breach sink/counter, DEM, cleaners, items, FC re-use, doors undercut less than 1 in.
3F	1	82	51	511	1	ND	20	Y # open: 4 # total: 4	Y univent furniture	Y closet (off)	DEM, items hanging from CT.
3E	1	82	48	543	1	ND	20	Y # open: 0 # total: 4	Y univent	Y ceiling (off)	Hallway DO, DEM, PF, TB, items, plants.
3D	1	77	43	443	1	ND	18	Y # open: 0 # total: 2	Y univent	Y closet (off)	window-mounted AC, PF.
3C	1	73	43	491	ND	ND	20	Y # open: 0 # total: 2	Y univent	Y closet	Hallway DO, window-mounted AC, DEM, FC re-use, window-A/C operating with hallway door open.
3B	17	78	43	595	ND	ND	20	Y # open: 0 # total: 4	Y univent	Y closet	Hallway DO, window-mounted AC, DEM, FC re-use, window-A/C operating with hallway door open.

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Indoor Air Results

Date: 06/07/2005

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D1	11	80	52	585	ND	ND	27	Y # open: 2 # total: 2	Y univent	Y ceiling	Hallway DO, DEM, PF.
D1	11	80	52	585	ND	ND	27	Y # open: 2 # total: 2	Y univent	Y ceiling	Hallway DO, DEM, PF.
D2	0	82	48	558	ND	ND	24	Y # open: 2 # total: 4	Y univent	Y ceiling	Hallway DO, DEM, items hanging from CT, plants.
3A	21	82	48	539	ND	ND	25	Y # open: 4 # total: 4	Y univent items	Y closet	Hallway DO,
2H	22	81	52	850	1	ND	24	Y # open: 0 # total: 3	Y univent dust/debris	Y closet	DEM.
SP6	3	80	43	688	1	ND	15	N	Y univent	Y closet	DEM, cleaners, wall A/C.
2G	23	81	51	681	1	ND	24	Y # open: 3 # total: 3	Y univent items	Y closet	Hallway DO, Inter-room DO, PF, aqua/terra, items, plants.

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845 Main Street, Leominster, MA 01453 **Table 1** **Date: 06/07/2005**

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									Supply	Exhaust	
2F	5	81	51	741	1	ND	21	Y # open: 1 # total: 2	Y univent items plant(s)	Y closet	Hallway DO, Inter-room DO, DEM, PF, cleaners, unlabelled bottles.
library computer lab	6	77	34	798	ND	ND	14	N	Y univent	Y ceiling	DEM, skunk-like odor.
library	23	80	46	754	ND	ND	18	Y # open: 0 # total: 6	Y univent items furniture	Y ceiling	Hallway DO, PF, 30 computers.
speech A	1	82	45	784	ND	ND	17	N	N	Y ceiling dust/debris	Inter-room DO, PF.
speech B	1	83	44	770	ND	ND	18	N	N	Y ceiling dust/debris	Inter-room DO, PF.
guidance	0	82	45	489	ND	ND	20	N	Y univent	Y ceiling	Hallway DO,

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main office	3	79	42	602	ND	ND	21	N	Y ceiling	Y ceiling	Hallway DO,
principal's office	0	76	42	616	ND	ND	22	N	Y ceiling	Y ceiling	Inter-room DO,
1A	18	81	51	680	ND	ND	28	Y # open: 1 # total: 4	Y univent items furniture	Y ceiling items	Inter-room DO,
1B	0	81	50	572	1	ND	26	Y # open: 1 # total: 4	Y univent boxes items furniture	Y closet items	Hallway DO, Inter-room DO, breach sink/counter.
1C	0	80	49	594	1	ND	25	Y # open: 0 # total: 4	Y univent	Y ceiling	Hallway DO, breach sink/counter, DEM.
1D	18	80	52	817	1	ND	25	Y # open: 0 # total: 4	Y univent	Y closet	Hallway DO, breach sink/counter, DEM, PF, cleaners, items.

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									Supply	Exhaust	
1E	16	81	49	584	1	ND	27	Y # open: 0 # total: 4	Y univent	Y closet	Hallway DO, DEM, items.
K	0	81	50	422	ND	ND	32	Y # open: 3 # total: 0	Y univent	Y ceiling	Hallway DO, Exterior DO, DEM, PF, items, items hanging from CT, plants.
1G	0	81	49	414	1	ND	24	Y # open: 0 # total: 0	Y univent	Y ceiling	Inter-room DO, breach sink/counter, DEM, PF, plants.
1H	0	81	50	459	1	ND	23	Y # open: 0 # total: 6	Y univent	Y ceiling	Inter-room DO, DEM.
T1	11	82	51	535	1	ND	27	Y # open: 2 # total: 2	N	Y ceiling	Inter-room DO, DEM, PF, FC re-use.
Reading/ESL	5	79	51	637	1	ND	18	N	Y univent	Y closet	#MT/AT : 1, work being performed in ceiling plenum area.
2A	0	79	50	543	ND	ND	26	Y # open: 1 # total: 2	Y univent	Y closet	Hallway DO, #WD-CT : 1, DEM, items.

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2B	22	80	51	615	ND	ND	26	Y # open: 3 # total: 6	Y univent items furniture	Y closet	Hallway DO, DEM, PF, plants.
2C	24	80	53	743	ND	ND	25	Y # open: 2 # total: 6	Y univent	Y closet	DEM, PF, items hanging from CT.
2D	18	81	50	811	1	ND	25	Y # open: 2 # total: 4	Y univent	Y closet	DEM, PF, plants.
1B	3	79	49	728	ND	ND	19	N	Y univent		Hallway DO, Inter-room DO, items.
2E	19	76	48	1624	ND	ND	18	N	Y univent	Y closet	AD, cleaners, pets, rubber cement, chemical like odors, univent-A/C dripping .
cafeteria	50	81	58	593	ND	ND	21	N	Y wall	Y wall	

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